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Sub-Picosecond Laser Deposition of Thin Films

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The 1999 Nobel Prize in Chemistry recognized the importance and growing maturity of the femtosecond time-scale in science and engineering. Understanding the interaction between materials and high energy density light to manufacture and process materials has become a key issue in both programmatic and fundamental research at Lawrence Livermore National Laboratory. We have emphasized in this research the aspects related to producing thin films by ablation of material with intense ultra-short laser pulses.

Our effort during FY2000 has been focused on building the foundation of this research using high purity graphite as the initial ablation material. We have deposited diamond-like carbon (DLC) in vacuum, measured ablation rates, and characterized the physical and chemical properties of the films. We successfully completed our first objective to compare the microstructure and materials properties of the films deposited using lasers operated in the femtosecond and nanosecond pulselength regime. The mechanical characterization of the deposits showed improved film-substrate adhesion properties that allowed us to build 200-µm thick layers using 150 fs pulses. Films produced with ns-pulses delaminated as soon as the thickness reached only a couple of microns. The stresses in the films were greatly influenced by the fluence and the duration of the laser pulses. The microstructure and surface morphology of the films did not vary significantly with the processing parameters studied (pulse length and fluence). Finally, we demonstrated that it is possible to significantly increase the deposition rate with shorter pulses at a given fluence. In particular, carbon could be deposited at a rate of 25 µm/hour with this technology.

Our goal in FY2001 is to study and model the relationship between the ablation plume characteristics (energy, charge, mass, and momentum) and the film growth behavior in order to influence and optimize the deposition process. We also want to determine if the laser parameters influence the stoichiometry of the deposits when compounds or alloys are used as ablation targets. We plan to investigate materials such as TiC, SiC, AlN, and polymers for the study.